Designing Effective Insect Resistance Management Programs for Bt Crops

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Abstract

Insect resistance management (IRM) for Bt crops is of great importance, because the development of insect resistance to Cry toxins threatens the longevity of effective Bt plant-pesticides. The U.S. EPA has identified eight components which should be considered when developing country-specific IRM programs. These components are: 1) pest biology, 2) dose, 3) cross-resistance, 4) refuge, 5) modeling, 6) resistance monitoring, and 7) compliance assurance. The socio-economic factors which govern country-specific regulatory agencies will determine how each of these components is addressed.

IRM = strategy to mitigate the development of insect resistance to an insect control measure

Building an IRM Plan: Four Questions

1. What is the probability of resistance development?
2. What are the strategies to delay/mitigate resistance?
3. Are resistance management strategies working well?
4. How will resistance management strategies be adapted if/when resistance occurs?

IRM Challenges

- Pests/crop considerations are country specific
- Adoption/distribution of a Bt crop will affect selection intensity on insect pests
- Practicality and feasibility of the IRM strategy will affect implementation of the plan
- Cost of plan implementation to growers, industry, and the government/regulatory agencies
- Accountability for adherence to IRM plan
- Geography of region where IRM plan is implemented
- Crop production practices in region where IRM plan is implemented

Critical Components of Effective IRM Plan

Pest Biology

Important pest biology factors include number of insect generations per year, number of different plant hosts, insect movement and dispersal patterns, mating and ovipositional behavior, and population dynamics.

Dose

Dose = the amount of toxin expressed by a transgenic crop relative to the susceptibility of a target pest. Dose can be determined through field efficacy trials or laboratory bioassays.

"**High dose**" = a level of toxin at least 25 times greater than the amount needed to kill all susceptible target insects; high dose is preferred over low dose events for refuge-based IRM strategies.

Cross-Resistance

Cross-resistance = when resistance to a single Bt toxin confers pest resistance to a cluster of related toxins. Cross-resistance to Bt toxins could minimize the long-term benefit of Bt technology.

Resistance Monitoring

Monitoring for pest resistance can help to prolong the benefits of a transgenic crop. Monitoring programs generally consist of:

- Field Surveys or reports of unexpected pest damage in transgenic fields from growers; and
- Laboratory bioassays to proactively detect potential resistance before crop failure in the field.

If resistance is confirmed, a **Remedial Action Plan** is implemented to limit or contain the spread of resistant pest populations.

Refuge

Refuge = any host plant (non-Bt corn/cotton, alternate hosts) that does not produce Bt toxin and has not been treated with conventional Bt formulations. Refuges enable mating between resistant and susceptible adults, resulting in production of susceptible offspring. Refuge options include:

Refuge Strategies

Structured Refuge | Community Refuge | 80:20 bag-in-a-bag

Modeling

Models are useful tools for predicting the likelihood of resistance, for evaluating the durability of IRM strategies, and for helping to focus data needs. Model components include biological (pest biology, ecology, population dynamics), operational (dose, single/stsacked toxin(s), refuge), and genetic (R-allele dominance/frequency, cross resistance) factors.

Compliance Assurance

To ensure that growers implement approved IRM strategies, grower contracts, 3rd party grower surveys, on-farm field visits, and a tips and complaints hotline for non non-compliers are required.

Grower education about the need for IRM, and the grower's responsibility to implement the approved IRM program, is key to the success of any compliance assurance program.

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